

Replaceable Microfluidic Cartridges for a PCR Biosensor

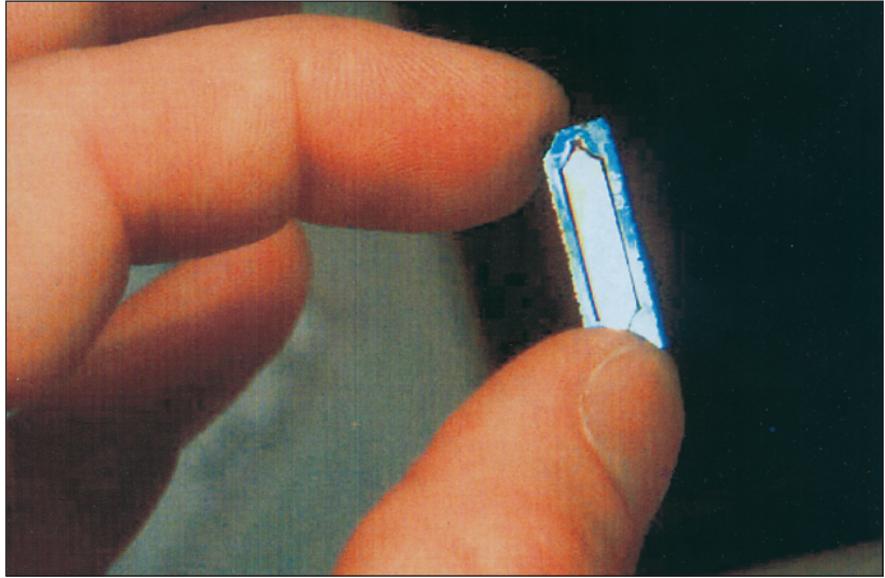
Design has been optimized for detection of target DNA sequences.

Lyndon B. Johnson Space Center, Houston, Texas

The figure depicts a replaceable microfluidic cartridge that is a component of a miniature biosensor that detects target deoxyribonucleic acid (DNA) sequences. The biosensor utilizes (1) polymerase chain reactions (PCRs) to multiply the amount of DNA to be detected, (2) fluorogenic polynucleotide probe chemicals for labeling the target DNA sequences, and (3) a high-sensitivity epifluorescence-detection optoelectronic subsystem.

Microfluidics is a relatively new field of device development in which one applies techniques for fabricating microelectromechanical systems (MEMS) to miniature systems for containing and/or moving fluids. Typically, microfluidic devices are microfabricated, variously, from silicon or polymers. The development of microfluidic devices for applications that involve PCR and fluorescence-based detection of PCR products poses special challenges:

- Biocompatibility of materials is a major requirement. Contact of DNA-containing fluid specimens with silicon inhibits PCR. It is necessary to either fabricate a PCR microfluidic device from a suitable polymer or else micromachine the device from silicon and coat its interior surfaces with a suitable polymer.
- Recently developed polymeric materials from which other biocompatible microfluidic devices are made do not have the high thermal conductivity and low heat capacity needed to facilitate the rapid thermal cycling that is essential for efficient PCR.
- It is difficult to integrate spectroscopic windows into microfluidic devices. Thermal-expansion mismatches between silicon substrates and glass windows lead to failures of devices.
- Multiple passes of an excitation light



This **Microfluidic Cartridge** is a micromachined device that contains fluid specimens during PCR cycles and serves as an optical cell for detection of fluorogenically labeled DNA sequences.

beam are needed to obtain adequate sensitivity for detection; this need further complicates the problems of design and fabrication.

The design and fabrication of the replaceable microfluidic cartridges meets these challenges. The cartridges are made from a combination of materials, based on micromachined silicon substrates. The thermal-expansion-mismatch problem was solved by use of thick (3 mm) silicon substrates and anodically bonded thick (0.7 mm) covers made of borosilicate float glass. The fluorescence signal is enhanced by use of multipass optics, an essential component of which is a reflective film of chemical-vapor-deposited aluminum on a square glass plate affixed to the bottom of the cartridge by use of epoxy. The in-

terior surfaces of the fluidic channels are coated with dodecyltriethoxysilane.

The design of the cartridge has been optimized along with that of the rest of the biosensor for detection of target DNA in a microgravitational or normal gravitational setting. In a test, the biosensor was found to be capable of reliably detecting 600,000 copies of the human β -actin gene after as few as five PCR cycles.

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CdZnTe Image Detectors for Hard-X-Ray Telescopes

Image sensors are designed for high spectral resolution and low power consumption.

Goddard Space Flight Center, Greenbelt, Maryland

Arrays of CdZnTe photodetectors and associated electronic circuitry have been built and tested in a continuing effort to develop focal-plane image sensor systems for hard-x-ray telescopes. Each

array contains 24 by 44 pixels at a pitch of 498 μm . The detector designs are optimized to obtain low power demand with high spectral resolution in the photon-energy range of 5 to 100 keV.

More precisely, each detector array is a hybrid of a CdZnTe photodetector array and an application-specific integrated circuit (ASIC) containing an array of amplifiers in the same pixel pattern as that